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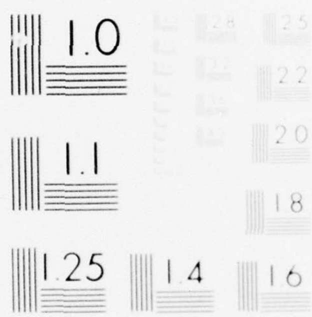
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Fort Belvoir, Virginia, 22060

CRAWFORD

A CASE STUDY

IN

RISK/DECISION ANALYSIS

PMC 73-1

Leslie P. Crawford
Lcdr USN

NOTE: Text on pages 39, 40, and 41 is complete.

A CASE STUDY IN RISK/DECISION ANALYSIS

An Executive Summary

of a

Study Report

by

Leslie P. Crawford
Lcdr USN

May 1973

Defense Systems Management School
Program Management Course
Class 73-1
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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DEFENSE SYSTEMS MANAGEMENT SCHOOL

STUDY TITLE:

A Case Study in Risk/Decision Analysis

STUDY PROBLEM/QUESTION:

To illustrate through the use of a case study the methodology for conducting a risk/decision analysis on a development program for a DOD weapons system.

STUDY REPORT ABSTRACT:

The increasing emphasis being placed on risk analysis in DOD has made the subject a focal point for program managers. The individual services are required to estimate or subjectively determine the risk inherent in their programs by conducting a risk assessment. The case study developed in this report is an attempt to inject a quantification of risk based on the facts available and the use of probability and statistics. A decision analysis is then applied to assist the decision maker in definitizing his options on a dollar basis. Various trade-offs and evaluation criteria are used to transfer the degree of risk to this dollar base. Each cost schedule, and performance parameter is treated on an equal risk basis.

KEY WORDS: MATERIEL ACQUISITION RETROFIT ACTIONS

RISK ANALYSIS COST ANALYSIS

Student, Rank Service	Class	Date
Leslie P. Crawford, Lcdr, USN	73-1	May 1973

Executive Summary

There has been an increasing emphasis placed on risk analysis in DOD. DODD 5000.1, entitled Acquisition of Major Defense Systems, has directed that meaningful relationships between need, urgency, risks and worth be established. As early as the conceptual phase of a program, the individual Service is to conduct a risk assessment before appearing at DSARC. DOD representatives at DSARC are looking for evidence that program risks have been identified and that appropriate action is planned for their resolution. To obtain a risk assessment, the individual Service goes through a process of estimating or subjectively determining the probability that a specific interplay of performance, schedule, and cost will not be obtained along the planned course of action. Although these types of qualified "engineering judgment" analyses are creditable, the kind of risk analysis presented in this case study will form the basis for a quantified type of analysis.

The case study is based on an actual risk/decision analysis performed by the Army's LANCE Project Office at Redstone Arsenal, Alabama. The methodology developed for that study was successful in identifying a program option for each production buy that would accomplish the program objectives. The methodology embodies the concept that the analyst should be able to use "fact" documents (present

status reports; demonstrated status reports; consultant reports; results of assessments by independent authors; etc.) to conduct an heuristic risk analysis and a decision analysis on his program. The heuristic analysis quantifies the probability of exceeding thresholds of schedule, cost, and performance associated with a decision. The decision analysis treats the sensitivity of decisions and trade-offs and states the optimum decision or approach to be taken. The objective in the decision analysis is to reduce the risks associated with each option to a common base, such as dollars. It should be stressed that the decision maker must still judgementally assess the "unquantifiables" in the case and make the final decision.

A CASE STUDY

IN

RISK/DECISION ANALYSIS

Presented to the Faculty

of the

Defense Systems Management School

in Partial Fulfillment of the

Program Management Course

Class 73-1

by

Leslie P. Crawford
Lcdr USN

May 1973

Contents

The Saber Missile Case Study

As Col. Gil Gruff left the conference room, the words of General Snuff (PM for the Saber Missile System) were still ringing in his ears. "This program has reached a point in its life cycle where it should be ready for production. With DSARC III only two months away (Sept. 1, 1973) there are still some requirements that have not been met on this system. There has to be some way of identifying the risks involved before entering production. We must be able to recommend some valid approach to the production phase at DSARC." As deputy program manager, Col. Gruff had been directed to consider the use of risk analysis as a management tool in arriving at a viable option for the production phase.

Background

Saber is a highly mobile, surface-to-surface, ballistic missile system which will provide a nuclear and non-nuclear capability in general support of Army forces. The Army plans for the Saber to replace the Navigator Missile System, which has been deployed for ten years. The target for overseas deployment (OSD) of Saber is Sept. 1, 1974. The initial guidance system has been specially designed to

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This paper represents the views, conclusions and recommendations of the writer and does not necessarily reflect the official opinion of the Defense Systems Management School nor the Department of Defense.

Developed by Leslie P. Crawford,
LCDR, US Navy, PMC 73-1.

give Saber a high degree of accuracy.

Saber has been in development for four years and has completed only the engineering tests. Performance was found to be less than required in two areas:

	Achieved	Required
In-flight reliability (prob)	.7(14/20 shots)	.75
Accuracy (Mils)	1.5	1.0

Other system characteristics are:

Range (Kilometers)	50-1000
Weight (missile + vehicle; lbs)	10,000
Launch vehicle	Cross country mobile, armored, amphibious vehicle

The number of systems required to counter the projected threat are 5,000 Saber missiles with warheads, and 100 launch vehicles. The Saber requires only 5,000 troops for support in the field whereas the Navigator System requires 10,000 troops.

Present Situation

Col. Gruff had access to the development documents for the Navigator System, so he began to analyze some of the data involved as well as the decisions made on that program. There was no indication that a risk analysis had been performed prior to entering the Production Phase. But the system had been in the field for a long time and the pervailing political climate at the time it was developed

allowed the incurrence of considerable expense to insure that performance was optimized. Col. Gruff knew that times had changed. The dollars were limited and no program would pass DSARC without the service having paid considerable attention to the risks involved - risks in cost, schedule, and performance. Usually an analysis of the risks in a program would manifest itself in the identification of several options which management could consider before proceeding.

About that time, Col. Gruff received a call from Col. Savage who was his Program Element Monitor in the Pentagon. Col. Savage related several of his impressions of OSD management, since he had sat in on several of the DSARC sessions recently. Apparently there was wide usage being made of risk analysis in determining whether a program was ready to proceed into the next phase. Savage indicated that there were a couple of program managers who had defended their programs quite successfully in this area; Col. Harvey Coal, and Col. Curly Huff.

Later on that day Col. Gruff decided to call the program managers that Savage had mentioned and invite them over for a chit-chat on risk analysis. Col. Coal, the program manager for the Snafu Missile System, just happened to be available that very afternoon. His program office was at Redstone Arsenal, but he was in town as a guest lecturer at American University on decision analysis. In the conversations that followed in Col. Gruff's office, Col. Coal

explained how he had used risk/decision analysis in his own program. Snafu was a surface-to-surface missile system employing fluid guidance with a mid-course programmed flight profile and laser terminal homing (maximum range 300 miles). Col. Coal had acquired the program approximately nine months before it was due to enter production. Based on engineering tests which had just been completed, he immediately initiated a risk analysis study to determine what action he should take concerning the production decision. Figure 1 shows the decision tree that Col. Coal developed in order to graphically depict the three options considered:

Option I

Start production right away.

Option II

Wait one year to start production and continue R & D for six more months.

Option III

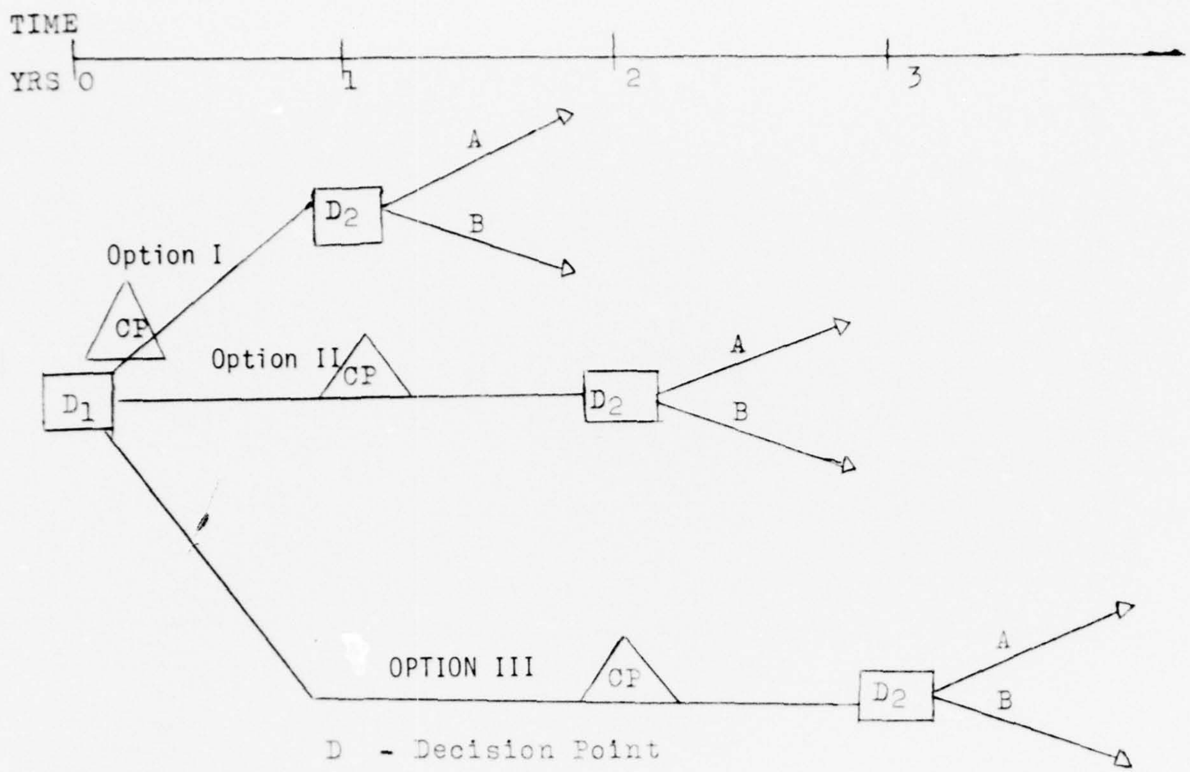
Wait two years before starting production.

There were two suboptions available for each of the options:

Suboption A. Accept the performance of the produced item if performance was within reasonable bounds. Reasonable bounds in this program were considered to be as low as 65 per cent reliability and 1.5 mils CEP; however, if the performance was within these limits but below the specified values (.75 reliability and

Figure 1

Decision Diagram for Snafu



D - Decision Point

CP - Commit to Production

A - Accept Performance

B - Retrofit to Correct Performance

1.0 mils CEP), more missiles could be purchased to cover the required number of targets.

Suboption B. Retrofit all the missiles at some point after production was started.

Col. Gruff then asked, "Why did you consider going into production right away when you knew you were having problems meeting two of the performance parameters?"

Col. Coal explained that the advantages of an immediate production go-ahead included the following:

1. Snafu would replace existing fielded systems requiring more soldiers per weapon. When fully operational, Snafu would require 9,000 troops; the existing systems (Shamrock and Conqueror) required 11,000 troops. At $10,000 per year per soldier, Snafu would save $20 million annually.
2. It would delete the requirement for 6 months of additional R & D by the contractor.
3. The skilled people associated with the R & D effort could be transferred directly into the manufacturing phase and thus the program would enjoy the advantage of personnel continuity.

Col. Coal then explained that the risk analysis resulted in a listing of the cost, schedule, and performance characteristics considered and the probability that the expected values (the mean of the distribution) of the characteristics would not be met. (Table 1)

Table 1

Risk Analysis for Snafu

Characteristics	Options and Results					
	I-A	I-B	II-A	II-B	III-A	III-B
Program costs (in millions of dollars)	$520	$625	$566	$646	$613	$648
Time to deployment (in months)	21	24	33	35	45	46
Probability of not deploying within 21 months	.50	.98	1.00	1.00	1.00	1.00
Probability of exceeding cost goal of $550 million	.00	1.00	1.00	1.00	1.00	1.00
System reliability	.69	.75	.73	.75	.78	.79
Probability of meeting reliability goal of 75%	.00	.50	.09	.50	1.00	1.00
System accuracy (in mils CEP)	1.5	1.0	1.2	1.0	1.0	.95
Probability of meeting or exceeding accuracy of 1 mil CEP	.10	.50	.20	.50	.60	.65

"That looks mighty impressive, Harvey, but how do you calculate the probabilities?"

"It depends on the parameter," replied Col. Coal. "For instance, the probability of not deploying within 21 months (target of OSD) is rather obvious for Options II and III. The probabilities for I-A and I-B required a careful analysis of the uncertainties surrounding these events. They were determined by carefully constructing a distribution for each event (Figure 2), the probabilities being derived as shown. The other characteristics were handled in a like manner."

As the discussion progressed, Col. Coal shared with him some of the ground rules one might use in constructing the distributions of the cost and time characteristics.

Cost Ground Rules:

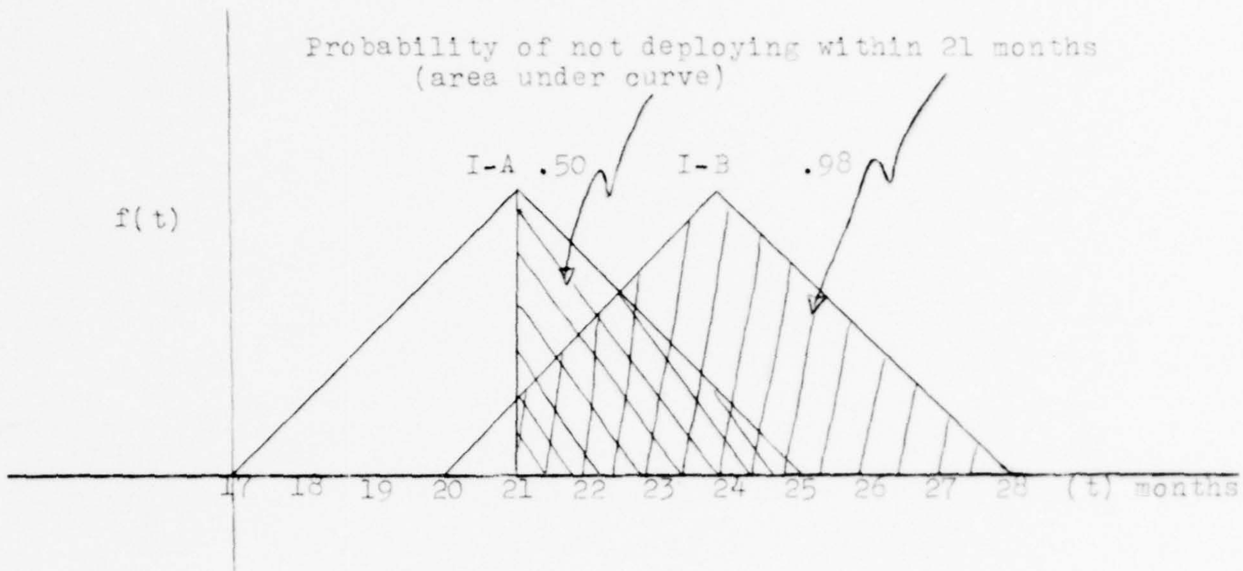
1. All costs include prior year costs.
2. Costs are discounted at the rate of 10% per year to equate all costs to present year purchasing power.
3. Future costs are based on projected remaining costs for procurement, R & D, and retrofit costs.

The following activities will generate costs:

1. Research and Development costs (R&D) to increase system performance to meet requirements.

Figure 2

Sample Distributions of Schedule for Snafu



2. Missile (including warhead) procurement costs.
3. Launch vehicle costs.
4. Retrofit costs. It is assumed that retrofit will increase system performance to required values, but at the risk of increased cost and time.

Time Ground Rules:

1. Nominal task completion times are used and are additive.
2. The expected time to start retrofit is one year from the decision date. The cause of low performance will be known, and the improved performance is expected to be demonstrated by that time.
3. Retrofit time includes redesign time, test time, remanufacture time and retrofit time.

Items 1 through 3 immediately above cause schedule slippage and are referred to as time generators. The time generators are arrived at using known facts. If facts are not available, best estimates from experts in engineering, programming, and scheduling must be used. The estimates are to be as realistic as possible (tolerances should be indicated as well as probabilities of occurrence), and the various options treated consistently. Various techniques are available

for soliciting and evaluating expert opinion.

Col. Gruff realized that he would have to be very careful in the assignment of his people in order to do a similar study on Snafu. He would need people knowledgable in the areas of system assessment, cost accounting and estimating, and scheduling.

"Did you make your decision given only the risk analysis data?" asked Col. Gruff.

"No, because those values do not provide any direct assistance in choosing the most attractive option," replied Col. Coal. "A decision analysis was then performed in order to transpose the expected values for all the parameters to a common base. The base that is best understood is the dollar base, and that's the one we used."

Col. Gruff found that one approach was based on a single computation of dollar costs using the expected values in Figure 1 and trade-off criteria (or figures of merit) in order to equate risk to cost. Criteria such as the following were used for Snafu: (Table 2 shows overall expected costs)

1. The time cost is the difference between maintaining the Shamrock/Conqueror Systems in the field, and maintaining the Snafu - multiplied by the months difference in deploying Snafu for the different options (21 months is the schedule goal).

Table 2

Option Costs

COST TITLE	I-A	I-B	II-A	II-B	III-A	III-B
Time	0	5	20	23.3	40	41.7
Program	0	105	46	126	93	128
Reliability	17.4	0	5.6	0	-7.4	-10.4
Accuracy	133	0	47.4	0	0	-9.8
Incremental Costs	150.4	110	119.0	149.3	125.6	149.5
Total Expected Option Cost	670.4	630	639	669.3	645.6	669.5

2. The program cost is based on the premise that each dollar spent, above the least costly option, would be a dollar cost.

3. Reliability cost is computed under the assumption that one is indifferent between system reliability and the number of missiles purchased as long as the reliability does not go below the reasonable bounds assigned.

   Reliability cost = Missiles required X Missile LCC

   where:

   $$\text{Missiles required} = \frac{.75 \times 1000}{\text{Assessed Reliability}} - 1000$$

   Missile LCC = \$200,000 (determined by cost experts)

   To the decision maker, this calculation equates risk to cost and does not imply an actual intent to purchase the additional missiles.

4. Accuracy costs are approached much the same way as reliability costs. A 1.5 mil accuracy is used as an example. Assuming a circular normal distribution, the object is to find the probability of a 1.5 mil accurate system impacting missiles within a 1 mil target radius. (1.1774 sigma = radius of a .5 probability circle)

   $$\frac{1.1774 \text{ sigma}}{1.5 \text{ mils CEP}} = \frac{X}{1.0 \text{ mils CEP}}$$

   $$X = .7849 \text{ sigma} \approx .265 \text{ probability}$$

The number of missiles required to insure that 50% will impact within the 1.0 mil radius is

$$\frac{750}{265} = \frac{X}{.5}$$

$$X = 1415 \text{ missiles}$$

This method also assumes an indifference to accuracy and the number of missiles procured without implying an actual intent to purchase this many more missiles.

"The option costs fall out neatly using that approach," commented Col. Gruff. "There is probably a more rigorous approach available, isn't there?"

"The decision tree approach, Gil. Instead of using just the expected value to compute the final cost of each option, the actual distribution for each parameter would be used in the tree. Sufficient sensitivity can be achieved by selection of only five points from the distribution and these points are then used to create the event fan for each parameter in the tree. The same distributions used to create the risk analysis matrix are used. Starting at the terminal point of the tree network, each event fan could be averaged out and folded back to eventually create one single monetary value for that particular option. This value should be approximately the same as that assessed using only the mean (expected) value for each parameter."

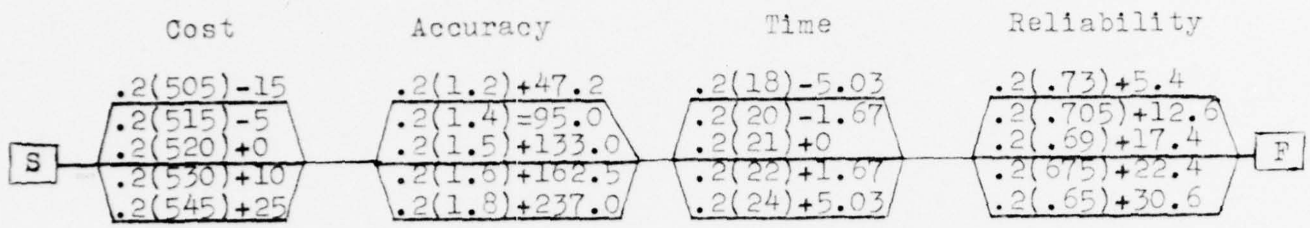
Figure 3 shows the tree network for Option I-A. The chance fork for .2(505)-15 under program cost indicates

Figure 3

Option I-A

Decision Tree Approach

Snafu Missile System



that there is a .2 probability that program cost will be $505 M. This is equivalent to a cost savings of $15 M. A solution of Option I-A resulted in the following costs equivalent to the risk involved:

Option I-A ($ Millions)	
Maximum	817.63
Expected	675.52
Minimum	552.57

The next morning, Col. Gruff called a staff meeting and parceled out the work assignments in order to construct a risk/decision analysis on Saber. He reminded his people that the cost goal for the program was still $500 M.

He also briefed his staff on the time and cost assumptions under which they were to work in developing the necessary data (same assumptions as those used for the Snafu missile system). Table 3 shows the data submitted by his cost estimating people. Figures 4 and 5 were developed by the same group in order to simplify the relationship between the levels of accuracy or reliability predicted and the number of additional missiles which equate to the risk. Figure 6 shows the decision diagram that Col. Gruff and his deputy developed. The diagram shows three options which (when analyzed) will aid General Snuff in deciding how he will present his program at DSARC.

Col. Gruff had explained to his system assessment people the value of a decision tree approach. LCOL Don Herta,

Table 3

Cost Data

Cost Per Tactical Missile

Cost Category	Discounted LCC
Missile Procurement	$ 62,750
Missile Depot Maint & Trans	11,140
Missile Spares, Provisioning Class V	13,250
Missile Storage and Support	22,860
	$110,000

Program Costs

Previous Program Costs	$400 M
Procurement costs (includes vehicle)	$110 M
R & D Program Cost	$50 M/Yr
Retrofit Cost	$4,000/Missile
Cost Per Man Year	$10,000

Figure 4

Accuracy Trade-Off Curve

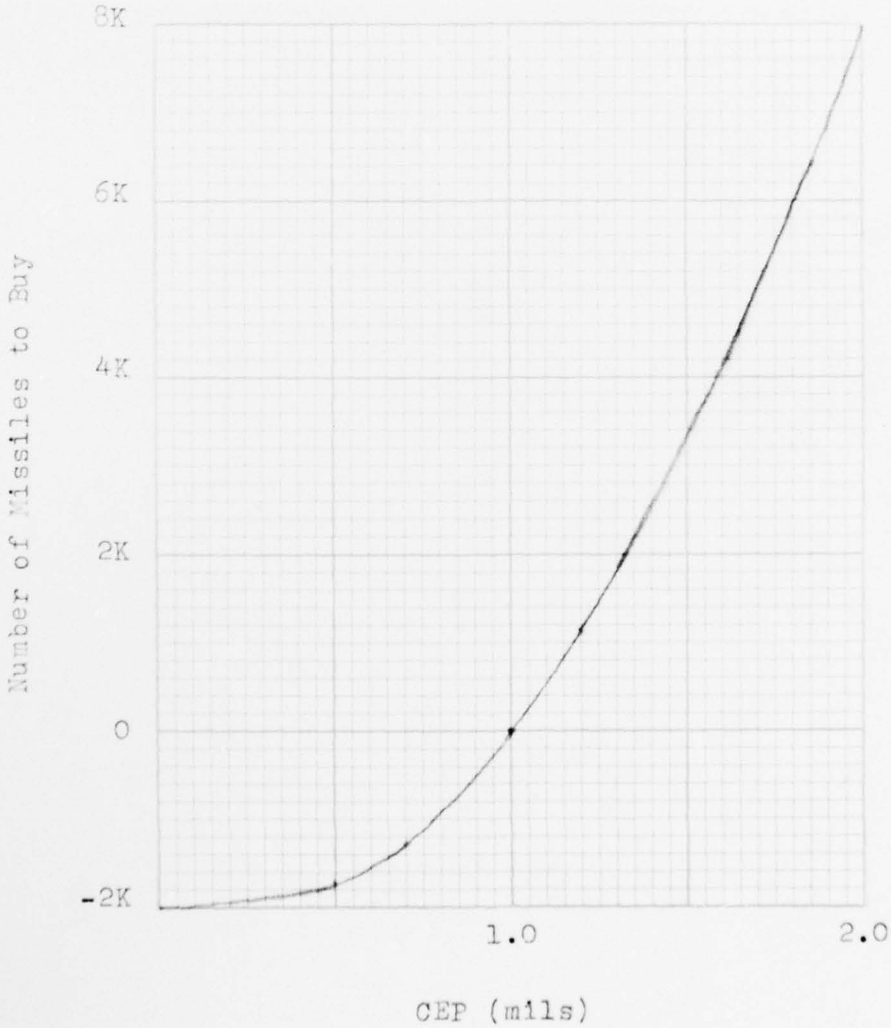


Figure 5

Reliability Trade Off Curve

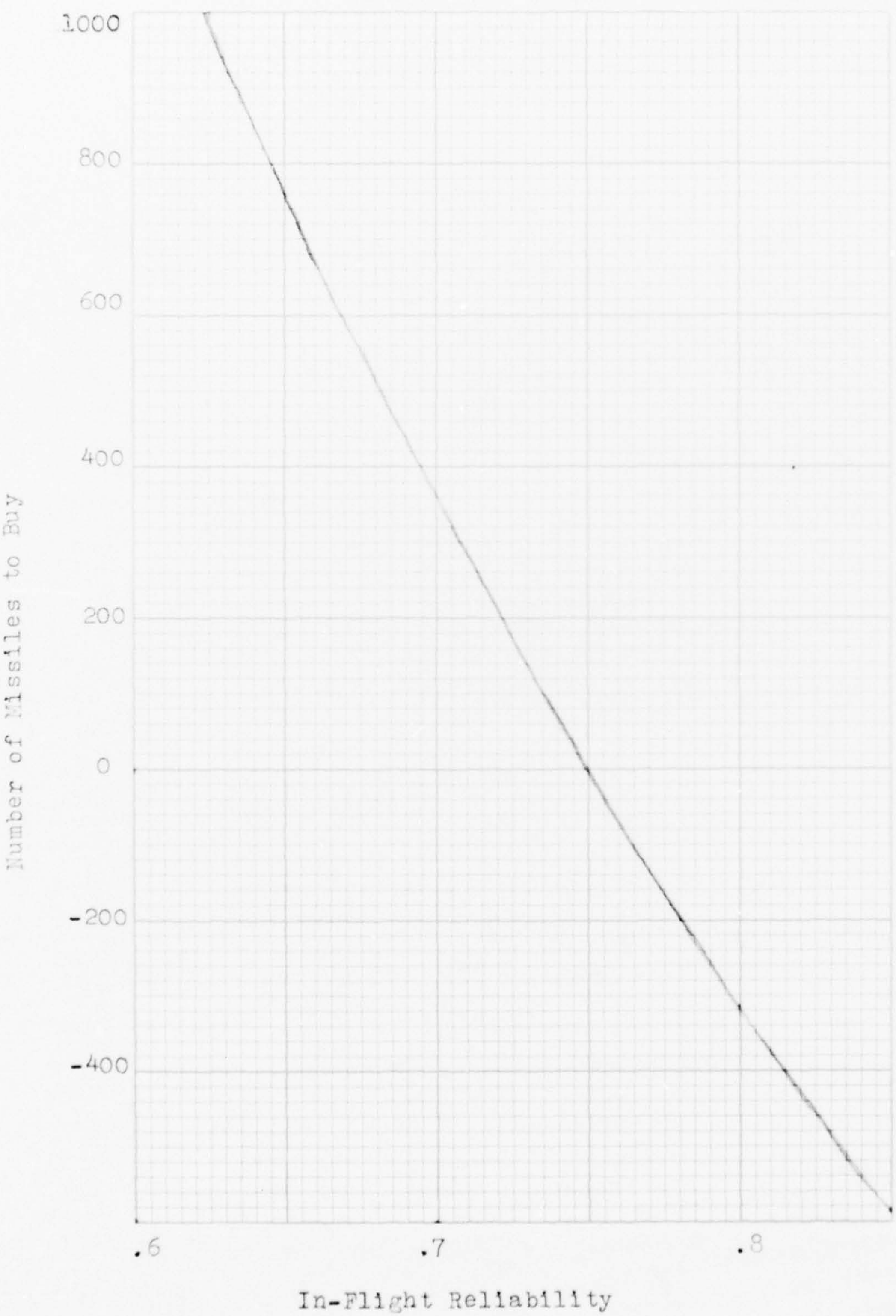
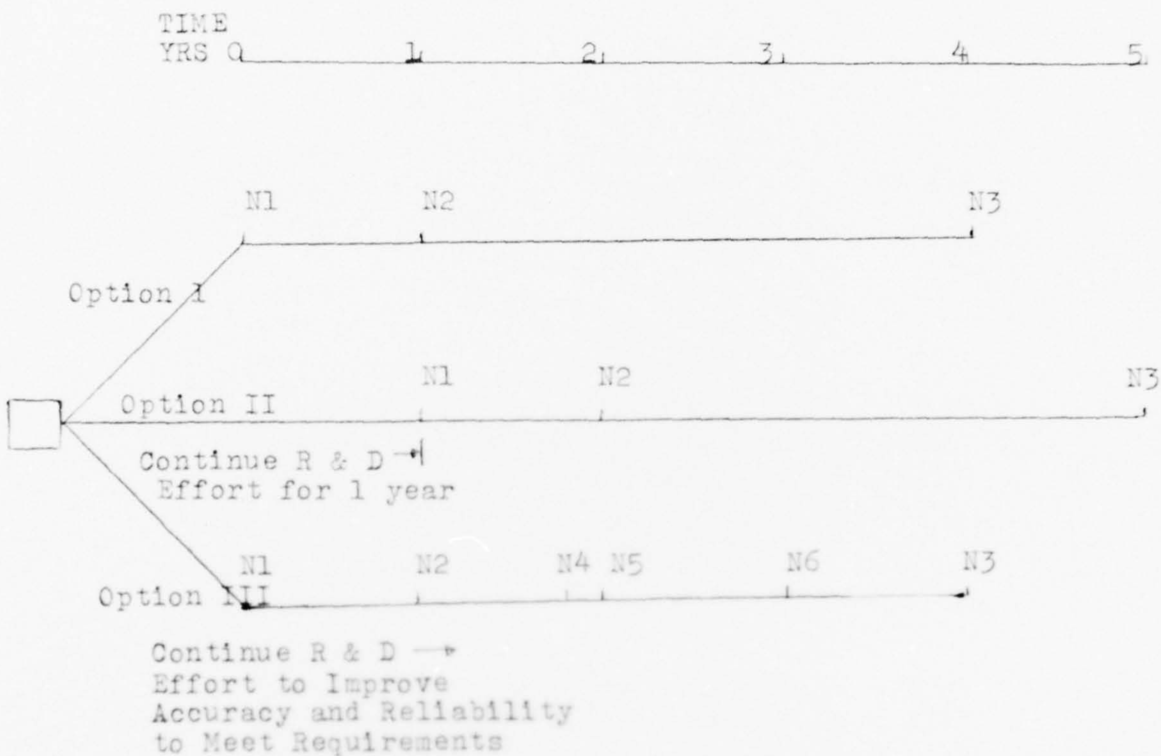


Figure 6

Decision Diagram for Saber



NOTES:

N1 = Award contract to start production.

N2 = First Saber system delivered to Army units. Start deploying Saber systems and phasing-out Navigator systems.

N3 = Last Saber system delivered to user. Navigator system phased out.

N4 = Expected time to start retrofitting fielded Saber missiles to improve their reliability and accuracy.

N5 = First Saber systems meeting performance requirements expected to be deployed by this time.

N6 = Design improvements to improve accuracy and reliability expected to be integrated into the production line by this time.

the Systems Engineering Division Head, latched on to the idea right away. From his background, he was able to recall valuable knowledge about sampling and distributions. Table 4 and Figures 7, 8, and 9 were submitted to Col. Gruff.

Once he had all the data, Col. Gruff created a special assessment group in order to facilitate the analysis. LCOL Herta was named chairman of that group.

Table 4

Distribution for the

Accuracy Parameter

Probability of Bracket	Bracket Medians (Mils)		
	Option I	Option II	Option III
.2	1.2	.7	.85
.2	1.4	.9	.95
.2	1.5	1.0	1.0
.2	1.6	1.1	1.1
.2	1.8	1.3	1.3

Figure 7

Cumulative Distribution of Reliability

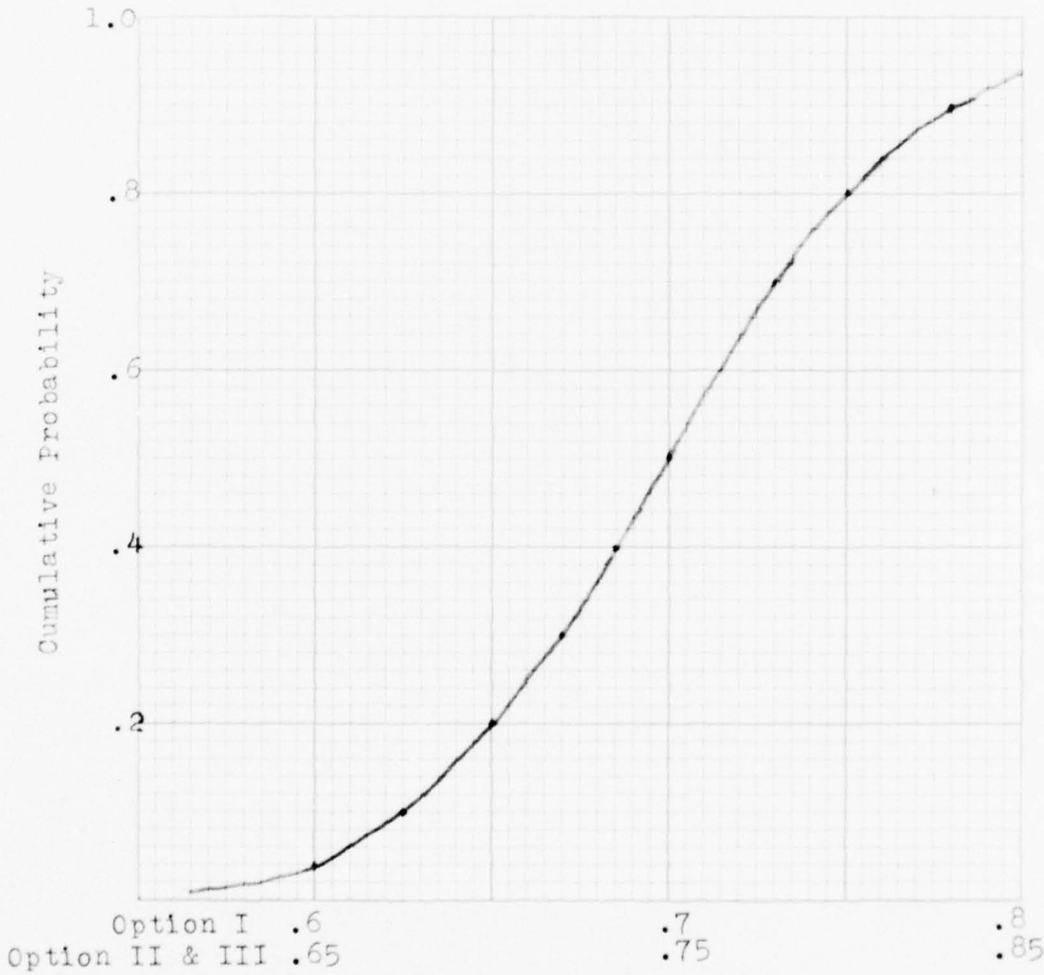


Figure 8

Cumulative Distribution of Schedule

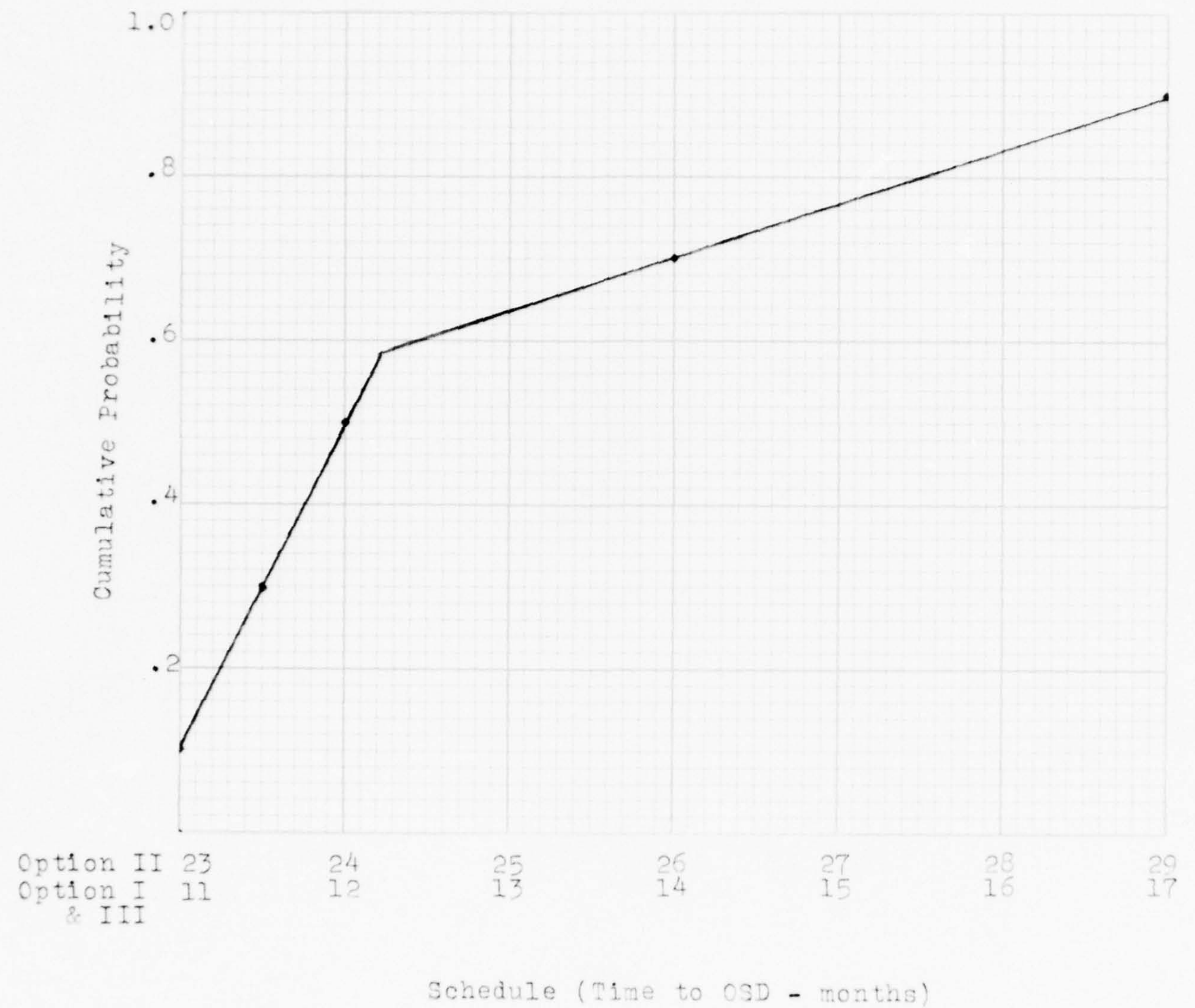
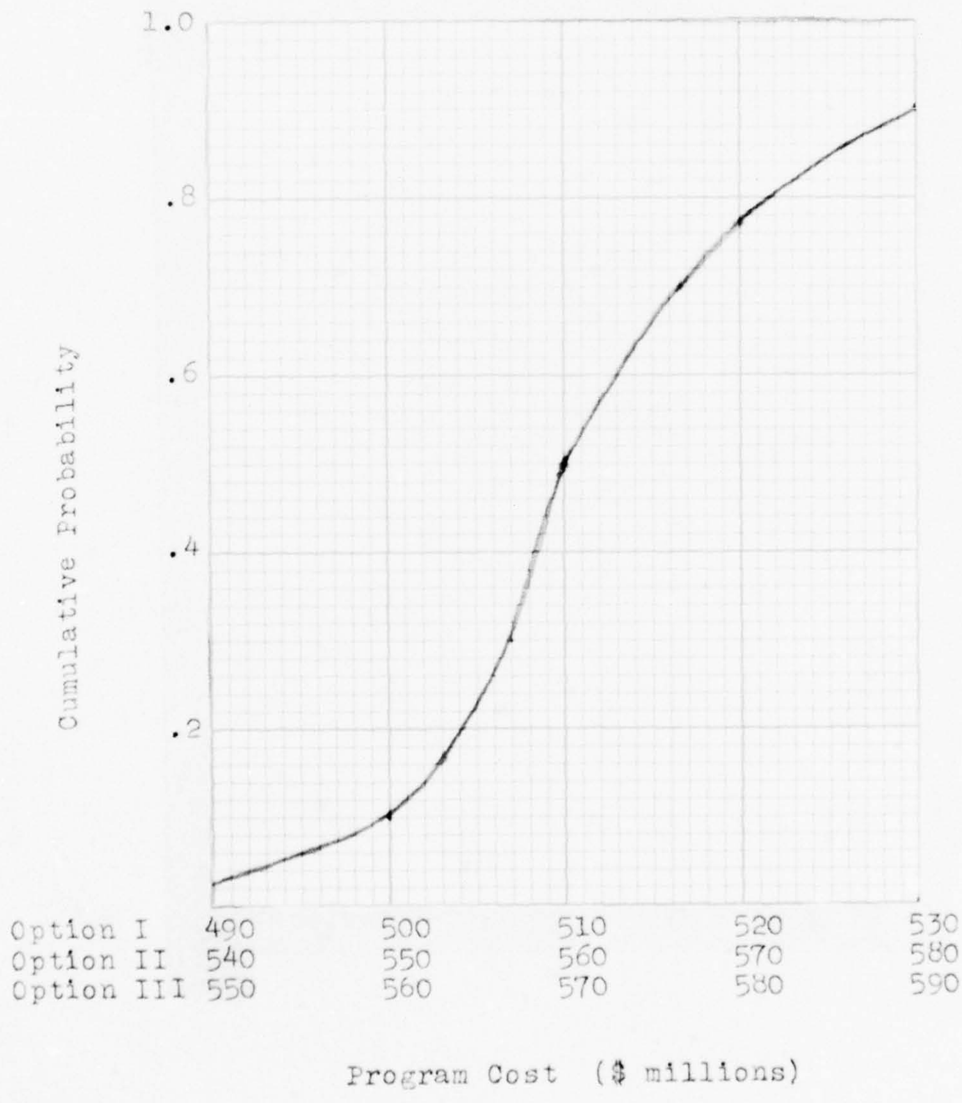


Figure 9

Cumulative Distribution of the Program Cost



Areas for Consideration

* Was Col. Gruff pursuing the right course of action?

* Does Col. Gruff have enough information to conduct a risk/decision analysis?

* How realistic are the criteria that were used to quantify risk?

* What are the advantages to conducting a risk/decision analysis? Disadvantages?

Instructor Notes

1. Risk analysis is a management tool, useful in presenting the alternatives to decision makers in such a way that the most attractive alternative is apparent. Risk analysis may be thought of as identifying the risks of exceeding established thresholds of cost, schedule, and technical performance.

2. A risk analysis is often thought of in qualitative terms, but it can be quantitative. However, the worth of the risk analysis is judged primarily by how well the reader can evaluate it. This means that the figures used must be documented in order for the reader to place any measure of confidence in the analysis. Documentation could be satisfied by a well developed derivation of a quantity.

3. Even in a risk analysis, some assumptions have to be made about the elements of cost, time, and performance. One of the most important assumptions addresses the interrelationship of these elements in a risk analysis; i.e., increased system performance can be obtained given enough time and sufficient funds.

4. Attachment No's 1 and 2 are the solutions to the risk analysis and the decision analysis, respectively, for the Saber missile system. The probabilities of achieving the expected values of the parameters for each of the options may be considered somewhat subjective based on how the

student interprets the tails of the distributions. Attachment No. 2 shows the solution using the expected value approach and the solution using the decision tree approach. Given the additional information (the maximum and minimum values) from the decision tree approach, the option selected by program personnel could be different. For instance, Option II could well be selected over Option III because there is an opportunity to bring the program in at a lower cost.

5. Schedule risk involves the identification and quantification of significant schedule contributors which could extend the program and result in delaying the OSD date. The following items contribute to schedule risk:

a. Manufacturing time for all hardware items.

b. Expected time and need for retrofit of those items determined to be major contributors to technical risk.

These times include:

(1) Requalification time for design changes.

(2) Manufacturing time for retrofit parts.

(3) Installation time for retrofit parts.

(4) Time for verification tests for design changes.

c. Overseas surface shipment time for hardware.

d. Overseas unit training time, where applicable.

6. In-flight reliability and accuracy are considered as independent technical risks under the simplifying assumption that if the flight is unreliable, it will be very inaccurate. Test procedures can be constructed such that a reliability circle, assuming a reasonable value for accuracy, would include 99.99% of all "reliable" missiles. Any missile impacting outside this circle is considered a failure for reliability testing, and is not part of the accuracy population.

7. The decision tree for each option of this case study is relatively easy to construct. For more complex trees there is a computer program called ADTREE which is commercially available to perform the calculations on a decision tree. With the aid of such a program the solution to a decision tree can be displayed in terms of cumulative probability versus expected cost, probability density versus expected cost, or discrete probabilities versus expected cost. The display should of course be presented in the manner that will be best understood by the decision maker. For this study, only the maximum, minimum, and expected values were computed for each option.

8. The expected time and cost of retrofit can be determined by processing the data obtained from data sheets such as those included as Attachment No. 3.

9. The student should discover that as the risk/decision analysis is constructed in this case study, the risk that

the total option cost will exceed the basic program cost ($510 M for the lowest cost program) has been computed on an equal risk basis. If the expected value and decision tree approaches had not resulted in one option clearly being the more desirable, additional treatments would have been necessary. Other treatments that could be used at this point are weighting and utilities.

Weighting would involve deciding if cost should have equal, less, or greater weight than schedule or performance. The utility approach would consider how much each of the parameters was worth to the decision maker. A relative standard could be established by considering the parameters in pairs, i.e., cost/time, time/performance, and cost/performances pairs.

A disadvantage in using a weighting factor is that individuals weight the parameters differently and this lends itself to dispute.

10. The risk costs used for reliability and accuracy were based on purchasing the additional missiles necessary to achieve the effectiveness that a system meeting the performance requirements would provide. The decision maker could elect to purchase the additional missiles, or he could set this risk money aside to be used as necessary in making later improvements. The method of assigning a dollar cost to each risk allows the quantification of costs for each

option on an equal risk basis.

11. There are some obvious advantages of a risk analysis that should be stressed:

a. Risk analysis forces derivation of quantified mean values, variances, and risk of exceeding established thresholds. With it, determination can be made of what the possible spread is, in values or risks.

b. Risk analysis forces the performance of sensitivity analyses on the various options to arrive at the optimum solution.

c. Risk analysis forces the evaluation of a program as a whole, rather than consideration of only parts of a program, when making a decision.

d. Risk analysis may contradict an intuitive management decision approach, causing the whole problem to be reevaluated and a more cost-effective decision to be reached. The analysis will not always provide a dominant strategy, but it will provide the decision maker with the predicted consequence of each course of action.

12. One criticism of the approach to risk analysis taken in this case study is the use of sunk costs as part of the overall program cost. DOD INST 7041.3 points out that sunk costs should have no bearing on current management decisions.

Notice that in the options selected, the sunk cost is a part of each option and in the final judgment of the decision maker it does not affect the relative outcome of the options. The risk for program cost is assessed by whether it has met the program cost goal which was established at the beginning of the development phase. However, the entire analysis could probably be constructed without the use of sunk costs.

Annotated Bibliography

1. Cuff, J. D., "Risk Analysis", Ordnance, May-June 1972, pp. 496-499. (UNCLAS)

   Gives an introduction to risk/decision analysis by presenting a case study to show the structuring of the risk matrix and the possible figures-of-merit the analyst can use to equate risk to a dollar base.

2. Cuff, J. D., Risk-Decision Analysis in Weapons System Acquisitions, unpublished, 16 May 1972. (UNCLAS)

   Presents a case study in risk/decision analysis to further demonstrate the usefulness of a quantification methodology in reducing risk in cost, schedule, and performance to a dollar base.

3.

4.

ATTACHMENT NO. 1

Risk Matrix

for the

Saber Missile System

CHARACTERISTIC	OPTION I	OPTION II	OPTION III
Time Risk			
Mean time until Saber units start replacing Navigator units, months	12	24	12
Probability of having Saber Army units start replacing Navigator units within 12 months (P_t), %	50	0	50
Cost Risk			
Mean cost, through production of 5,000 Saber missiles and 100 launch vehicles, in millions of dollars	510	560	570
Probability of not exceeding the cost goal (Pc) of $500 M, %	23	0	0
Reliability Risk			
Mean reliability of fielded missiles, %	70	75	75
Probability of meeting reliability goal (P_r) of 75% with fielded missiles	20	50	50
Accuracy Risk			
Mean accuracy, mils CEP	1.5	1.0	1.0
Probability of meeting accuracy goal (P_a) of 1.0 mils CEP, %	1	50	50

ATTACHMENT NO. 2

Decision Analysis Results

for the

Saber Missile System

Expected Value Approach
(Costs in Millions of Dollars)

CHARACTERISTIC	OPTION I	OPTION II	OPTION III
Time cost	0	50	0
Program cost	0	50	60
Reliability cost	39.27	0	0
Accuracy	365.75	0	0
TOTAL OPTION INCREMENTAL COST	405.02	100	60
TOTAL EXPECTED OPTION COST, including $510 M cost, for Lowest Cost Program	915.02	610.0	570.0

Decision Tree Approach
(Equivalent Cost in Millions)

OPTION	MIN	EXPECTED	MAX
I	600	915	1319
II	399	630	909
III	425	607	869

ATTACHMENT NO. 3

Sample Data Sheets

for

Costing Retrofit Procedures

ITEM, PART NUMBER, DASH NUMBER

Person completing each block of this form is to sign and date the block completed.

1. What is the achieved in-flight Reliability (R_a) of the item from all applicable tests to date? List the S/N this value was derived from, and define the tests and test conditions.

R_a = S/N ______ = / . Enter this value in the table

____
Name Date

2. What is the projected Reliability (P_r) of the item at future dates? $P_r = R_a + R_g$, where R_g is Reliability growth. Attach justification for R_g. Justification should include extent of design changes, and testing planned to verify these changes by each date. Enter the value of P_r in the table.

____
Name Date

3. What is the possible extent of rework (P_e) of the item? Fill in the table with the probability for each rework category, a through c, for each option. The summed probabilities of a through c must equal 1, $\sum_a^c P_e = 1$ for ea. op

Attach justification for these probabilities, such as: C = 100, the item cannot be reworked and must be scrapped.

____
Name Date

4. What is the cost of rework (COR) for each possibility for each option? Determine the minimum, median and maximum cost. In determining the min. and max. costs, exclude those extreme low and high costs that could be expected less than 1% of the time. The costs are to consider the following elements as applicable:

a. Removal and replacement of the item on the missile(or warhead) $________________(labor).
b. Rework on the item, or replacement of the item $______________(labor and material).
c. Gaskets, etc. that must be replaced in removal and replacement of the item $ ______________(material).
d. Packaging and shipping of item to vendor for rework $______________(services).
e. Total costs, a through d. $COR = \sum_a^d = \$$____________.

39

(Assume the missile (or warhead) is already at the depot and no missile (or warhead) shipping costs are involved.) Att a description of the removal and replace actions necessary to acquire the item for rework. Enter the values of COR in the table.

Name ____ Date ____

5. What is the time required to retrofit (TRR) the item? Determine minimum, median and maximum time in months. In determining the min. and max. times, exclude those extreme short and long times that could be expected less than 17 of the time. The times must include the following elements as applicable:

   a. Requalification testing on design changes ____________.
   b. Manufacturing of new item or component ____________.
   c. System verification flights of new item ____________.
   d. Shipping of new items to depot for installation ____________.
   e. Rework of item at depot ____________.
   f. Removal and replacement of item on missile ____________.
   g. Total time, a through f. The total time will be determined by the critical path "from the time the need to retrofit becomes known until the first retrofit has been accomplished". If there is parallel effort, TRR will <u>not</u> $= \sum_a^f$

Enter the values of TRR in the table.

Name ____ Date ____

6. What is the probability of retrofit (PRT) by Reliability analysis? Enter value of PRT in the table. The probability of retrofit is based on the present performance, projected performance, and expected performance gain from such a retrofit.

Name ____ Date ____

RISK ANALYSIS DATA SHEET

ITEM, PART NUMBER DASH NUMBER

Table for Information from Steps 1 through 6	OPTION I & II				OPTION III				OPTION IV				5. TRR	
1. Achieved in-flight Reliability (R_a)					Same				Same					
2. Projected Reliability (P_r)														
	3.	4. COR			3.	4. COR			3.	4. COR				
Retrofit rework extent	P_e	MIN	MED	MAX	P_e	MIN	MED	MAX	P_e	MIN	MED	MAX	MIN	M
a. Minor rework (Readjust or repair without disassembly)														
b. Intermediate rework (Replace or rework 1 or more parts)														
c. Major rework (Major disassembly and replacement or rework of 25% of parts, or scrap item and replace with new end item)														
6. Probability of Retrofit, (PRT)														

COMMENTS: